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LUMINARY Memo #149

To: Distribution  
From: D. Eyles  
Date: 13 May 1970  
Subject: Further Tests of ZERLINA

Along with the tests of the Variable Servicer version ZERLINA which were described in Luminary Memo #144 I ran tests designed (1) to further verify that in zero TLOSS cases ZERLINA performs like LUMINARY, and (2) to reveal any latent instability that may lurk in ZERLINA at high TLOSS. This memo, mostly plots, presents the results of these runs.

Velocity Spike Cases

In these tests lateral velocity spikes were abruptly incorporated into the LM state vector and vehicle reaction observed. The magnitude of the spikes upon incorporation was 45 cm/s in the direction of the stable-member y-axis. This is about 1.5 ft/s — the maximum one-pass change in the velocity vector for a radar weighting factor of .2 and a velocity reasonableness test limit of 7.5 ft/s. In fact the reasonableness test limit for Apollo 13 was 2.5 ft/s and the lower value will probably be kept, so the spikes used were impossibly big by a factor of 3. Each spike was input by an astronaut action conditional on the display of LPD time in noun 64 and actually enters the state vector a few seconds after the time at which TGO is the indicated -70 or -50 seconds. The spike cases run were these:

1. LUM 154. Spike at TGO -70.
2. ZER 16. Spike at TGO -70.
3. ZER 16. Spike at TGO -70. TLOSS 20%.
4. ZER 16. Spike at TGO -70. TLOSS 20%. LEADTIME 3 seconds.
5. LUM 154. Spike at TGO -50.
6. ZER 16. Spike at TGO -50.
7. ZER 16. Spike at TGO -50. TLOSS 20%.
8. ZER 16. Spike at TGO -50. TLOSS 20%. LEADTIME 3 seconds.

Unless otherwise indicated TLOSS is zero and LEADTIME is 2.2 seconds. The plots for CDUZ for these tests are on the following pages. Note that the ZERLINA and LUMINARY cases for zero TLOSS compare closely. The 20% TLOSS cases, especially for a spike at TGO -50, return to normalcy less quickly, due to a longer attitude control interval and slower correction of the velocity vector by the landing radar. Nevertheless the oscillations do not grow and instability is avoided. At this time in P64 with 20% TLOSS guidance period is around 2.6 seconds. The 20% TLOSS cases with LEADTIME set to 3 from the customary value of 2.2 seconds show little difference.

# CDUZ AND CDUZD

MARSROT NUMBER 08813545

LUMINARY LANDING WITH NOISE SPIKE AT TGO -70

-10

-5

0

-5

-10

-15

DEGREES



↑

P64

5000FT

↑

↑

1000FT

↑

500FT

↑

P66

↑

ENG OFF  
100MIN

3

SECONDS G.E.T.

388850

388900

388950

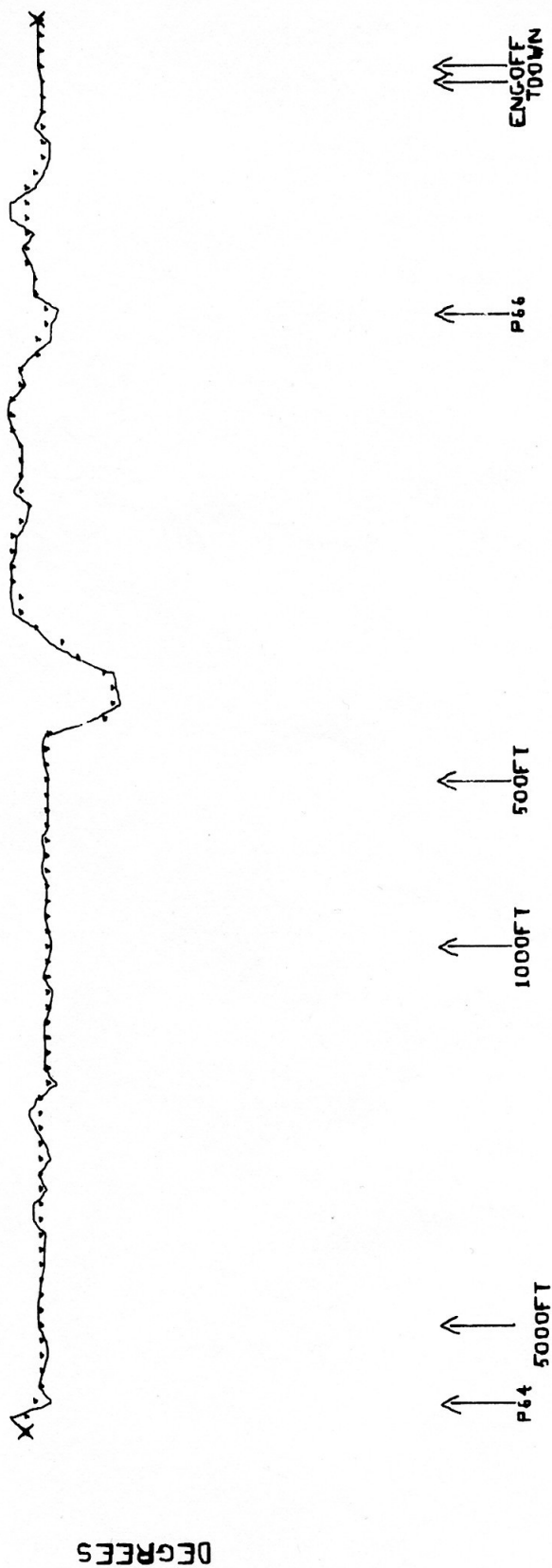
389000

OE

# CDUZ AND CDUZD

MARSROT NUMBER 08811494

ZERLINA 16 LANDING WITH NOISE SPIKE AT TGO -70



SECONDS G. E. T.  
388900

388850

389000

E



# CDUZ AND CDUZD

MARSROT NUMBER 08803360

ZERLINA 16 LANDING WITH NOISE SPIKE AT TGO -70 AND 20\* TLOSS

-10

-5

0

-5

-10

-15

DEGREES



P64 5000FT

1000FT

500FT

P66

ENG OFF  
100WN

SECONDS G.E.T.

388900

388850

388950

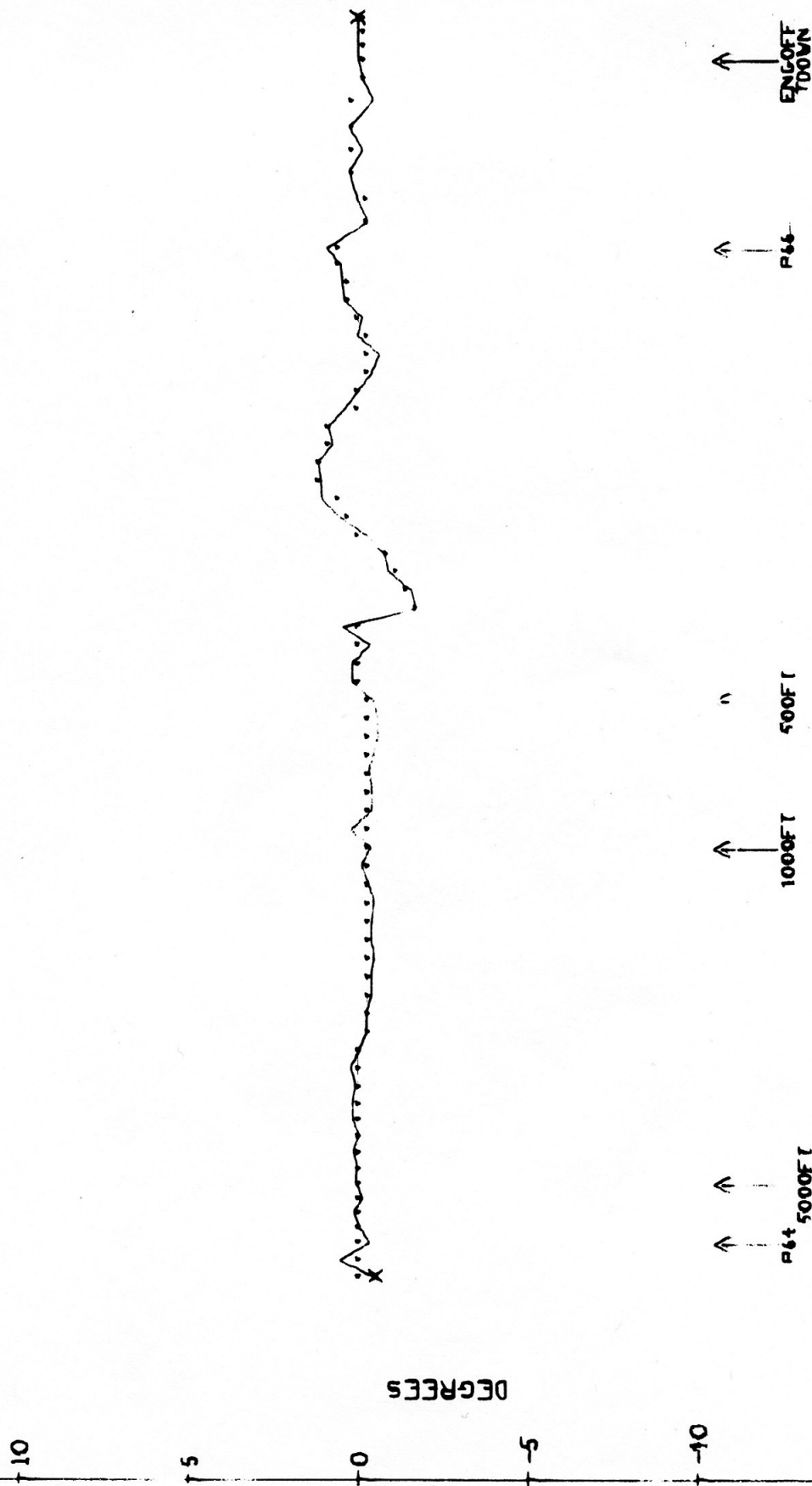
389000

E

# CDUZ AND CDUZD

MARSROT NUMBER 08803360

ZERLINA 16 LANDING WITH NOISE SPIKE AT TGO -70, 20\* TLOSS, LEADTIME 3



SECONDS G.E.T.

388850

388900

388950

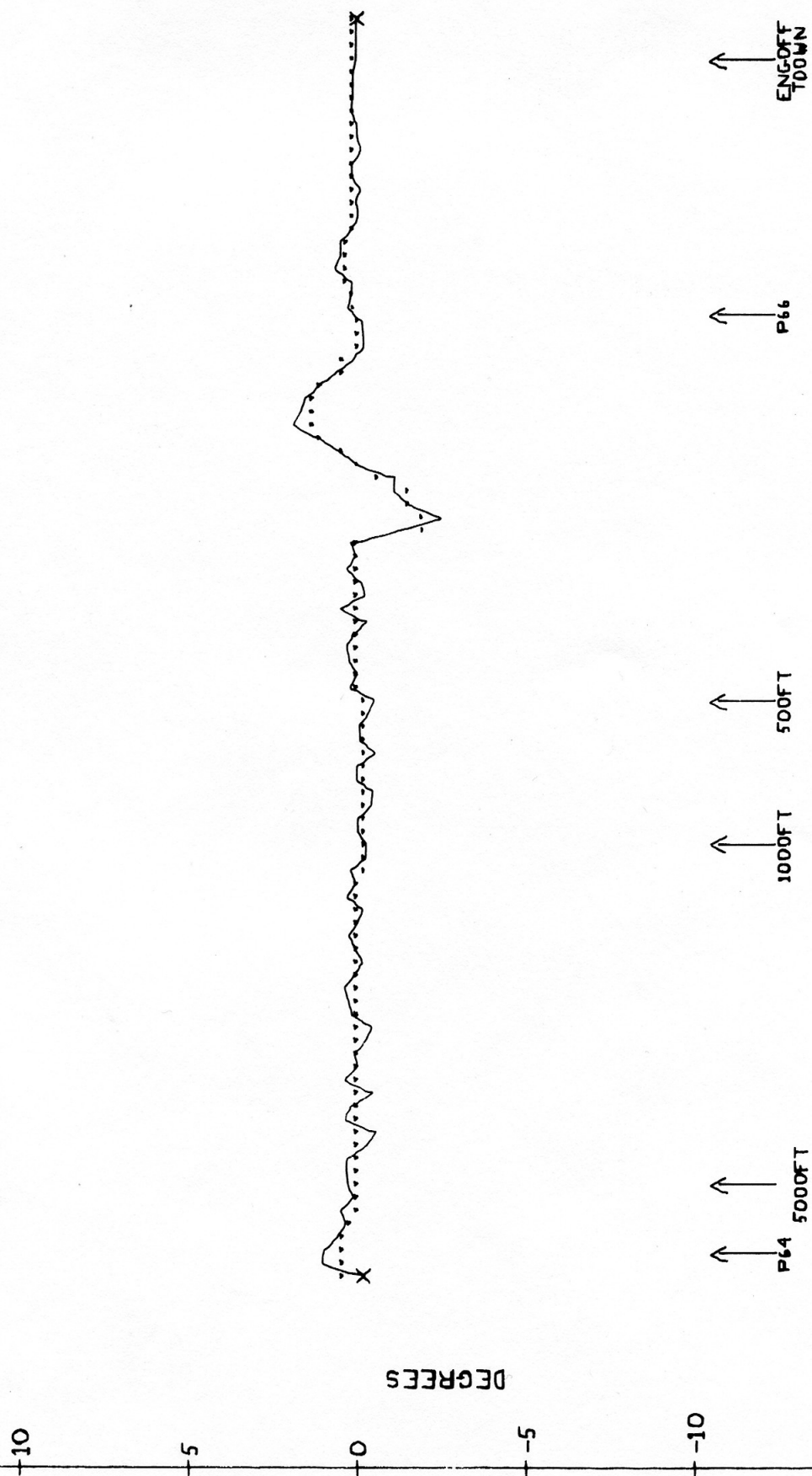
389000

CE

# CDUZ AND CDUZD

MARSROT NUMBER 08723183

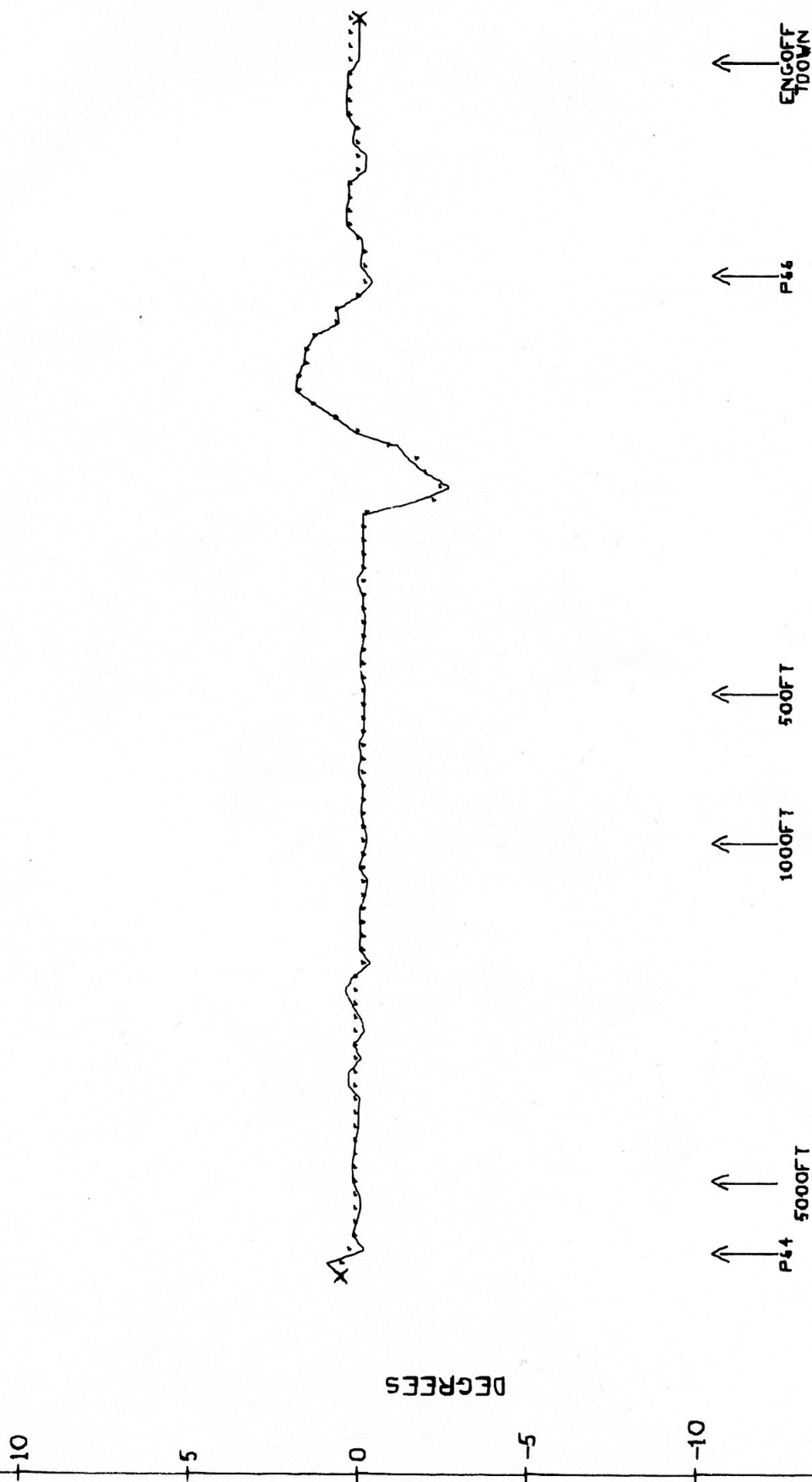
LUMINARY LANDING WITH NOISE SPIKE AT TGO -50



# CDUZ AND CDUZD

MARSROT NUMBER 08810425

ZERLINA 16 LANDING WITH NOISE SPIKE AT TGO -50



SECONDS G.E.T.

388900

388850

388950

389000

CE



# CDUZ AND CDUZD

MARSROT NUMBER 08802313

ZERLINA 16 LANDING WITH NOISE SPIKE AT TGO -50 AND 20\* TLOSS

DEGREES

-10

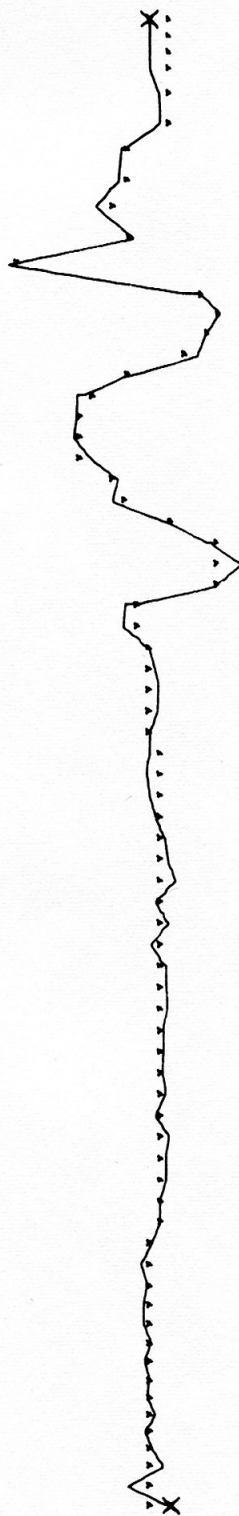
-5

0

-5

-10

-15



P64 5000FT

1000FT

500FT

P66

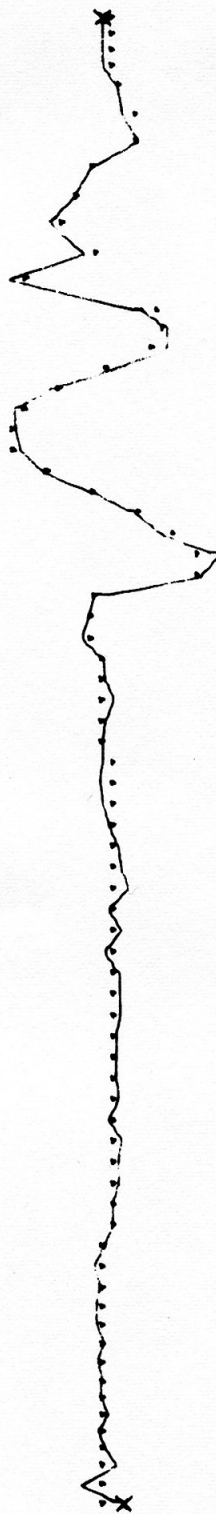
ENG OFF  
100WN

# CDUZ AND CDUZD

MARSROT NUMBER 08802313

ZERLINA 16 LANDING WITH NOISE SPIKE AT TGO -50, 20x TLOSS, LEADTIME 3

DEGREES



PLA 5000FT

1000FT

500FT

PLA

ENG OFF 1000W

### Redesignation Cases

In these runs 3 rightward (+ azimuth) redesignations were input at about TGO -50 seconds. The earlier cases perturb the velocity vector. These redesignation cases in effect perturb the position vector by shifting the landing site. The redesignation cases are these:

1. LUM 154. Redesignations at TGO -50.
2. ZER 16. Redesignations at TGO -50.
3. ZER 16. Redesignations at TGO -50. TLOSS 20%.
4. ZER 16. Redesignations at TGO -50. TLOSS 20%. LEADTIME  
3 seconds.

The reactions to these position "spikes" are shown in the CDUZ plots on the next pages. Again note that at zero TLOSS the LUMINARY and ZERLINA cases compare closely, and that unbounded behavior never results. Increasing LEADTIME from 2.2 seconds to 3 seconds somewhat improves the 20% TLOSS case. Possibly we may wish to increase LEADTIME to improve performance in very high TLOSS situations.



# CDUZ AND CDUZD

MARSROT NUMBER 08809394

LUMINARY LANDING WITH REDESIGNATIONS AT TGO -50

-10

-5

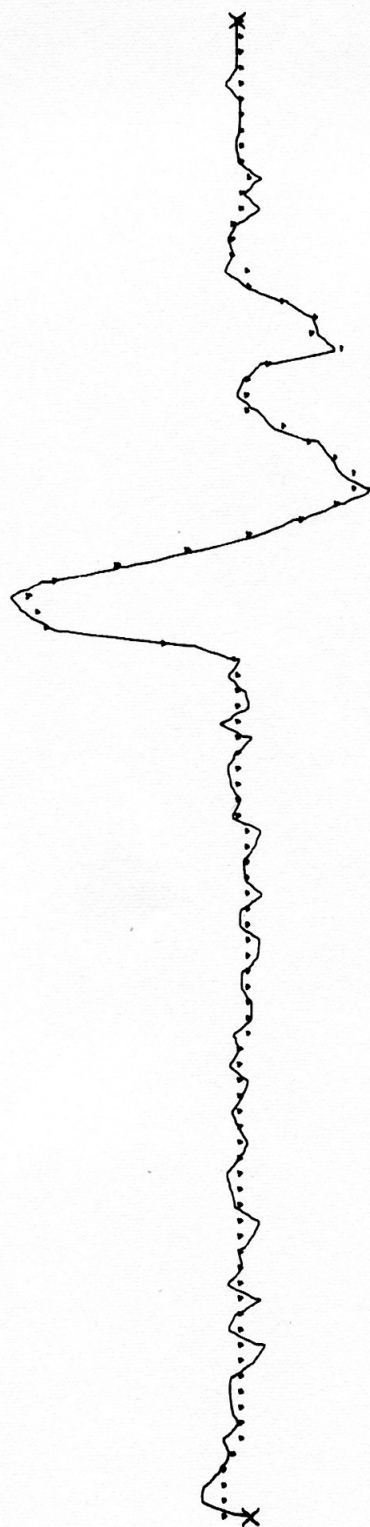
0

-5

-10

-15

DEGREES



P64 5000FT

1000FT

500FT

+AZ  
+AZ  
+AZ

P66

ENC OFF  
T DOWN

388850

388900

388950

389000

SECONDS G. E. T.

DE



# CDUZ AND CDUZD

MARSROT NUMBER 08900462

ZERLINA 16 LANDING WITH REDESIGNATIONS AT TGO -50

10

5

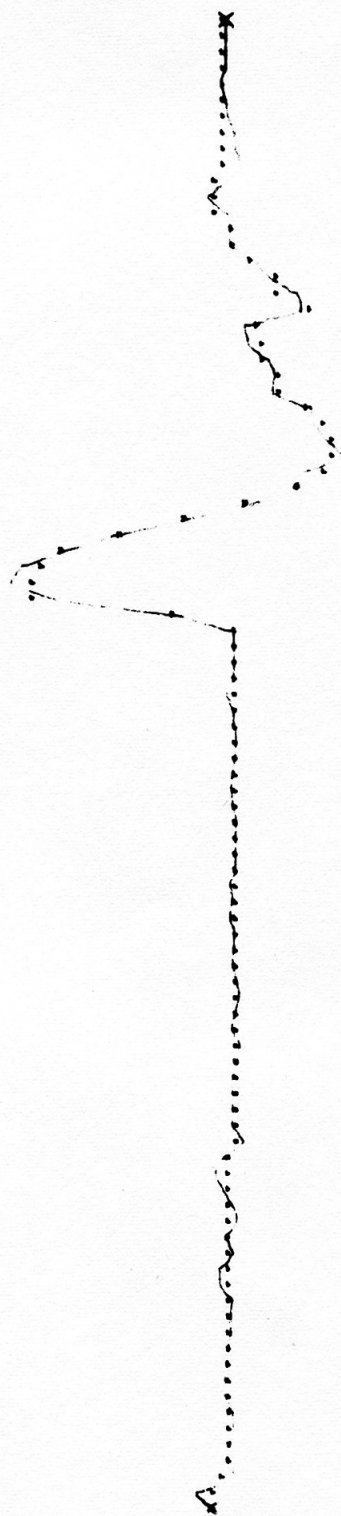
0

-5

-10

-15

DEGREES



↑  
P14 5000FT

↑  
1000FT

↑  
500FT

↑  
P17  
P17  
P17

↑  
P16

↑  
ENG OFF  
1000N

10

388850

388900

SECONDS G.E.T.

388950

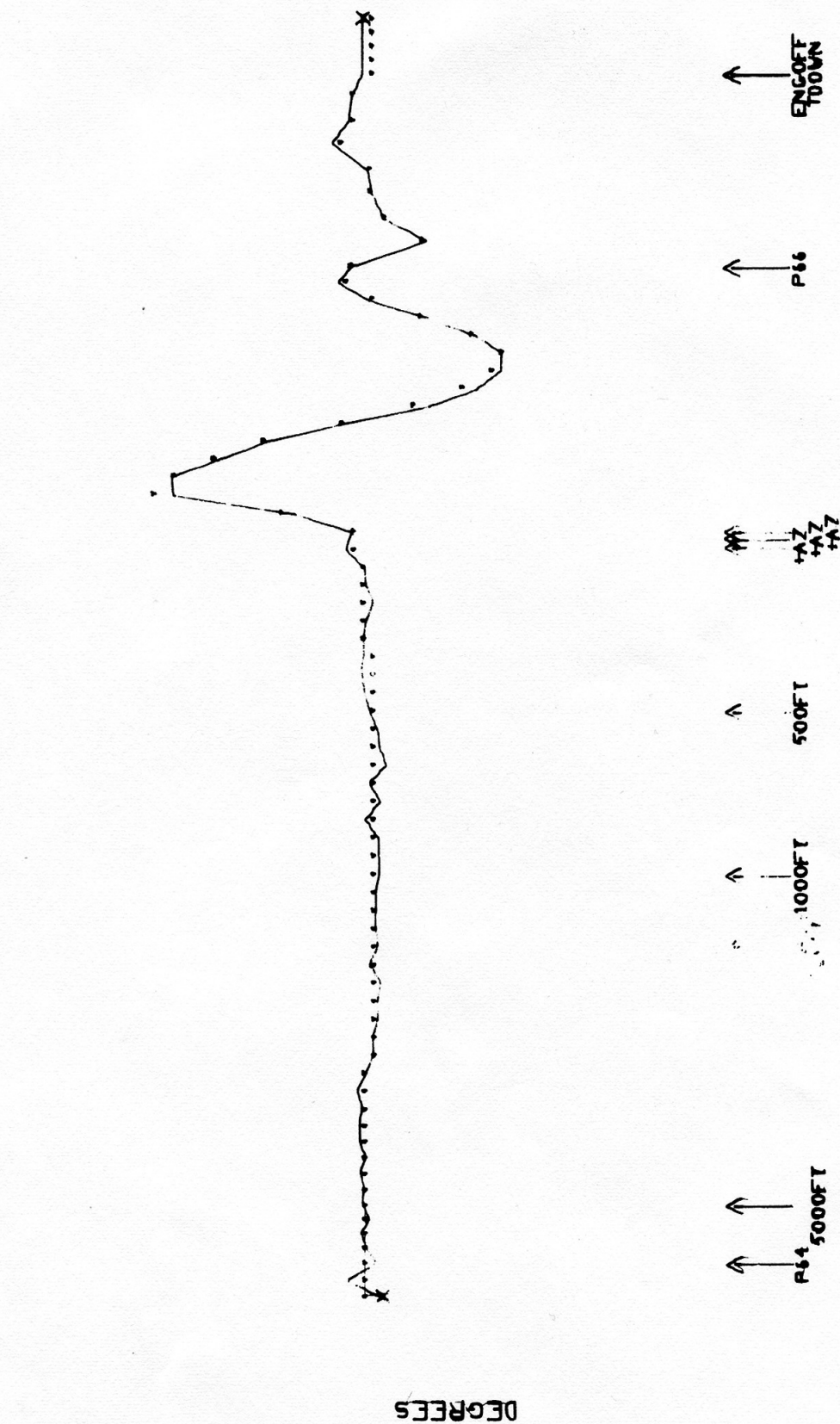
389000

DE

# CDUZ AND CDUZD

MARSROT NUMBER 08810032

ZERLINA 16 LANDING WITH REDES AT TGO -50, 20\* TLOSS, LEADTIME 3



### P66 Exercise Cases

In these runs at around 350 feet with a sink rate of about 3 ft/s and DAP mode in attitude-hold the ACA is used to give the vehicle about  $20^{\circ}$  positive roll. This attitude is held for 10 seconds, then mode is returned to Auto and the vehicle maneuvers to correct the lateral velocity (about 40 ft/s) that has built up. The P66 exercise cases were:

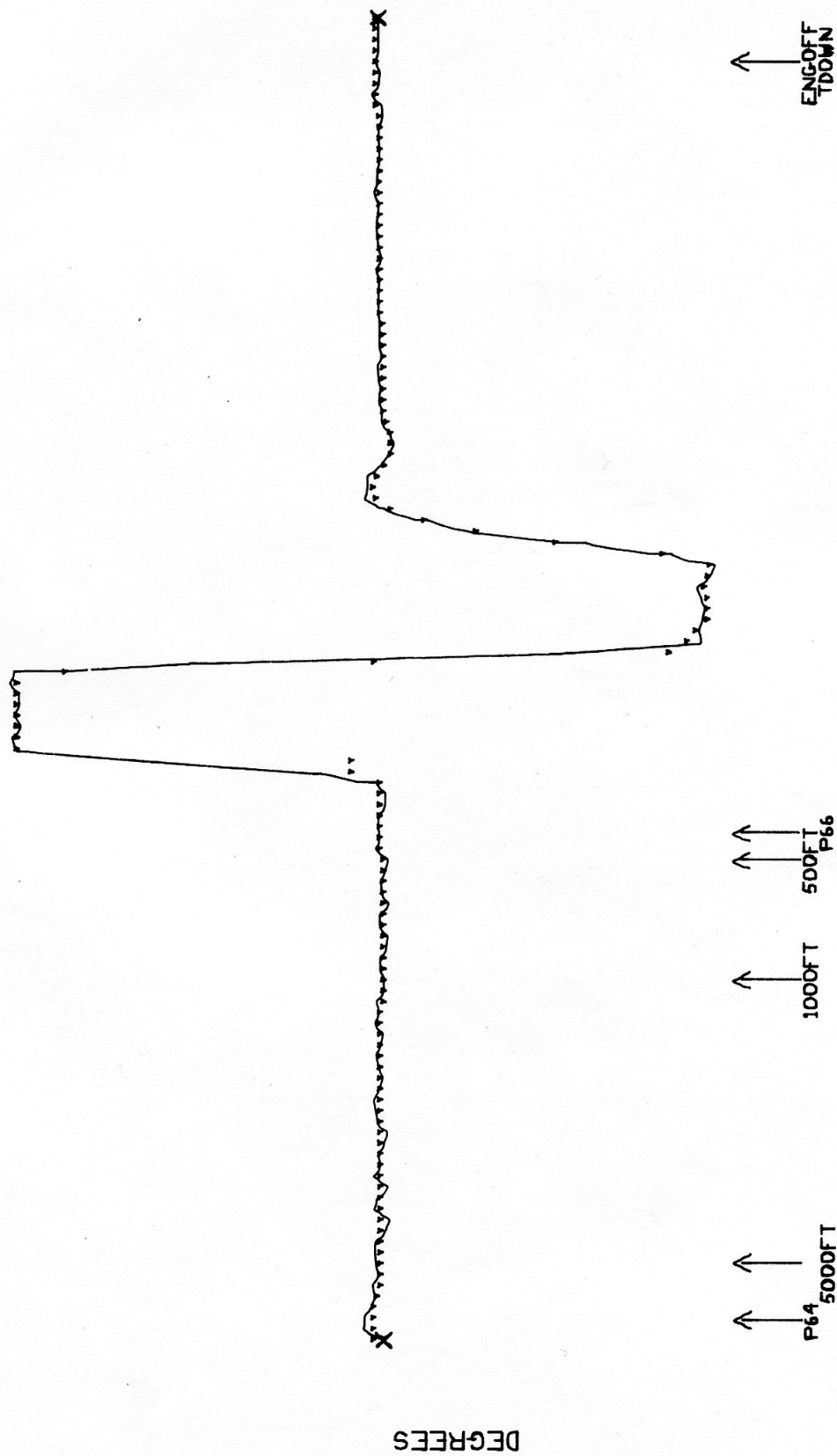
1. LUM 154. P66 exercise.
2. ZER 16. P66 exercise.
3. ZER 16. P66 exercise. 20% TLOSS.

The CDUZ plots follow. Note that in responding to the lateral velocity the attitude excursion limit (AHZLIM) built into P66 Auto prevents the vehicle from maneuvering more than  $20^{\circ}$  in the other direction, giving the plots a certain symmetry. The zero TLOSS cases perform the same. The 20% TLOSS case shows a slight overshoot when it maneuvers back to the vertical.



# CDUZ AND CDUZD

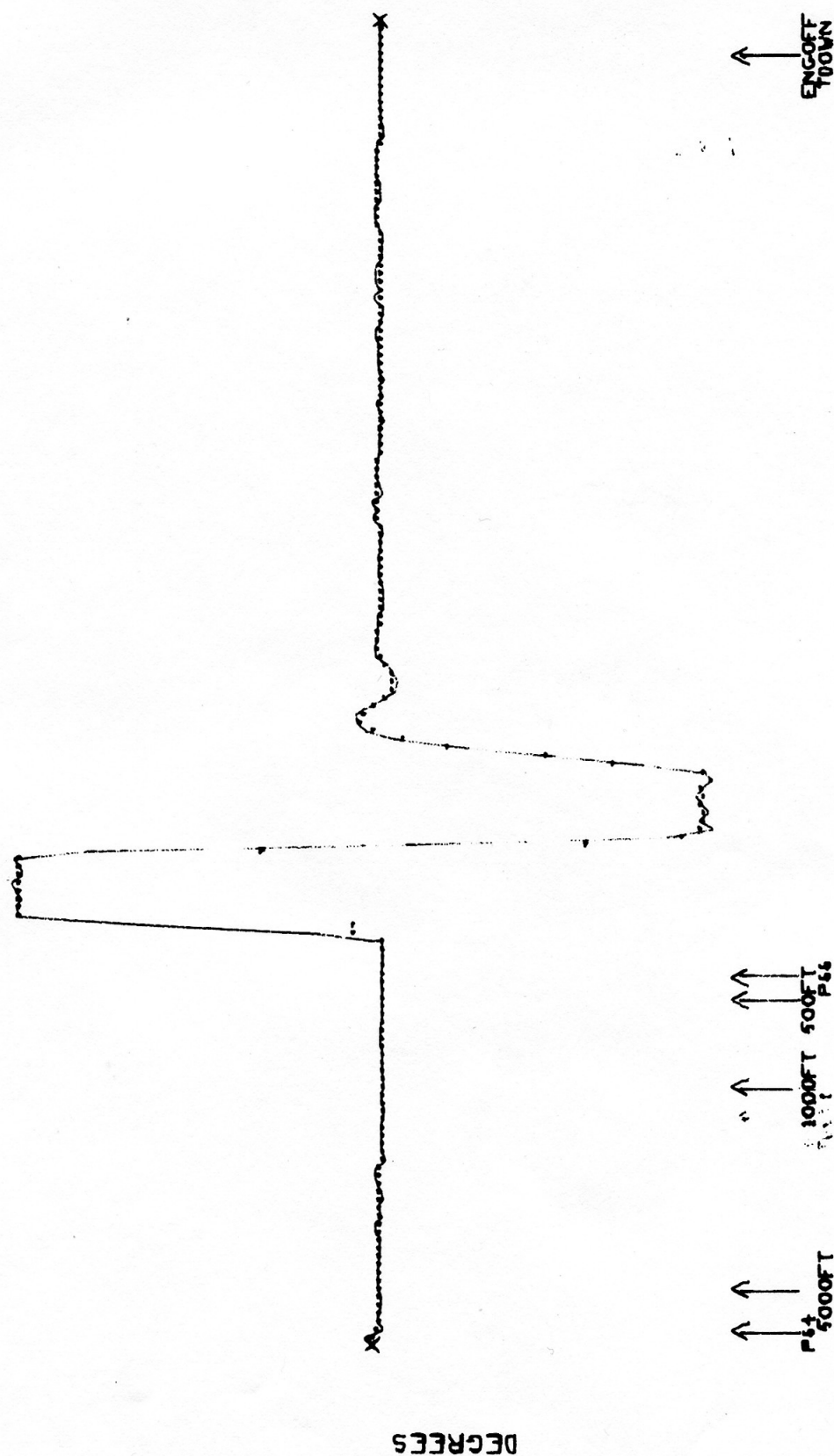
MARSROT NUMBER 08815093  
LUMINARY LANDING WITH P66 EXERCISE





# CDUZ AND CDUZD

MARSROT NUMBER 08721100  
ZERLINA 16 LANDING WITH P66 EXERCISE

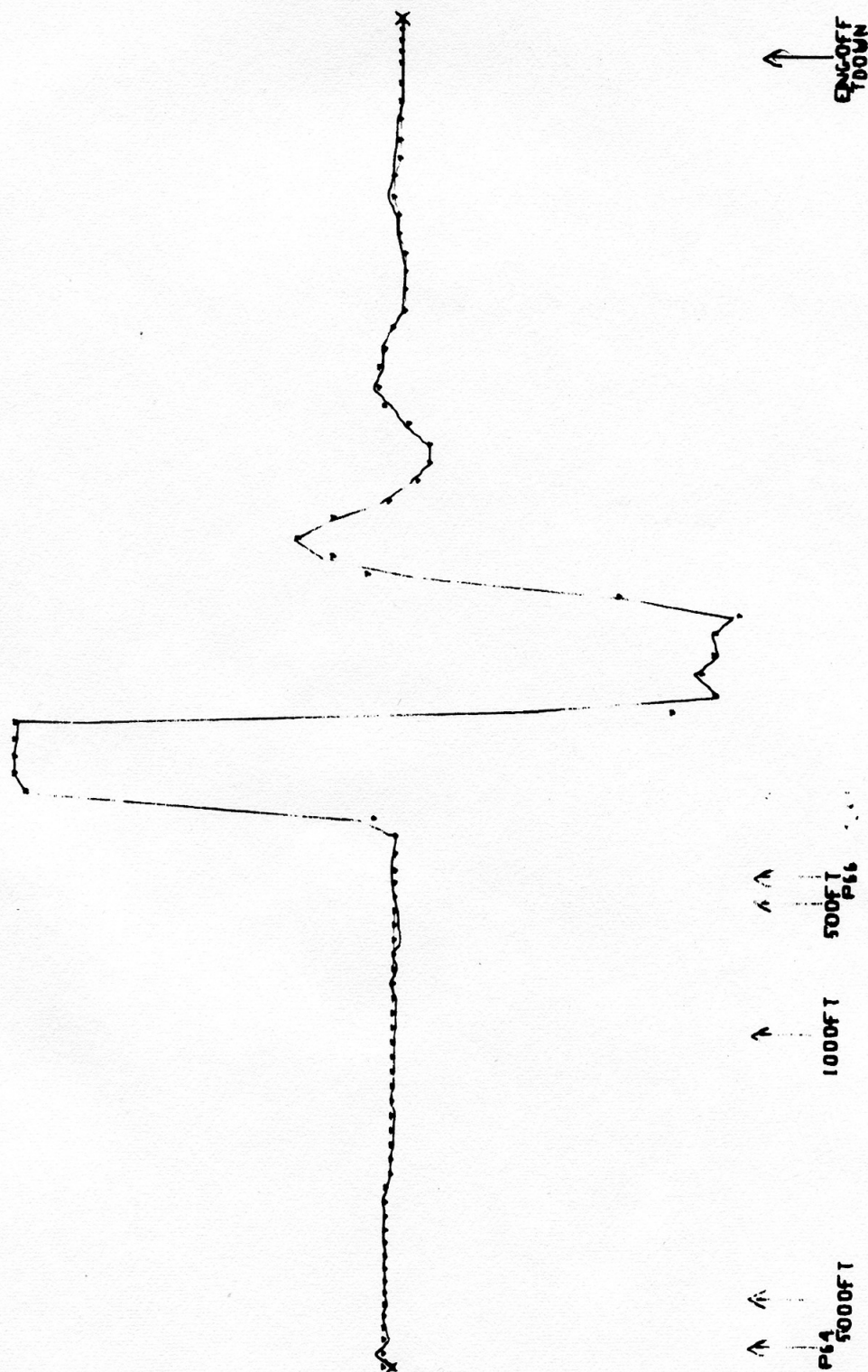


SECONDS G.E.T.

# CDUZ AND CDUZD

MARSROT NUMBER 08804071

ZERLINA 16 LANDING WITH P66 EXERCISE AND 20x TLOSS



SECONDS C.E. T.

38850

388900

388950

389000

389050

DE